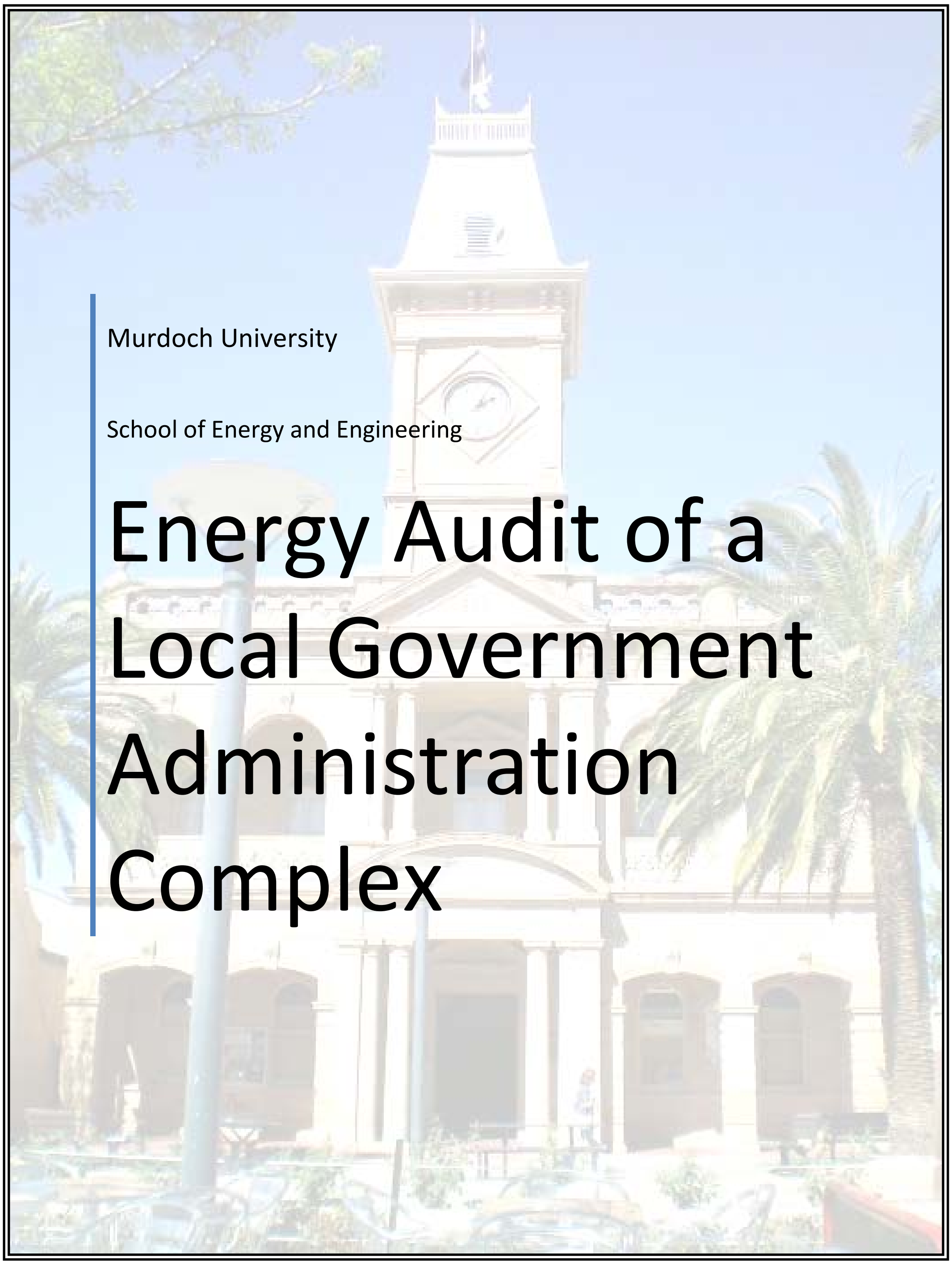

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Energy Audit of a Local Government Administration Complex

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The research and analysis presented in this dissertation are solely the work of the author. No other person or organisation contributed to the writing of the document.

Abstract

Local Governments in Australia are becoming more involved in the area of energy efficiency. The Southern Downs Regional Council in Queensland is an example of a council that is just beginning to move in this direction. There are several benefits to implementing energy efficiency measures in government operations. These include but are not limited to a reduction or delay in legislative liabilities relating to greenhouse gas emissions.

The research presented in this document takes a look at the energy use of the administration complex of buildings in Warwick, Queensland. The aim was to determine how much energy is used, and attempt to discern the proportional distribution of how and where the energy is being used in the buildings. This was done by examining the available historical data as well as through performance of walk-through audits of the buildings.

A literature review is presented to indicate how audits are carried out, and what types of energy efficiency measures are available for commercial buildings. Case studies in Australia and overseas are also included to show how successful projects are implemented.

The results of the historical and walk-through audits were analysed to determine where and how energy is used and furthermore to identify areas where improvement is possible. This analysis is presented, and based on the results and the literature review, several possible actions are recommended for further investigation by the Southern Downs Regional Council.

Overall, the results show that the Southern Downs Regional Council performs fairly well. However there is room for improvement in many areas, and with very modest investment, it may be possible to reduce energy costs by up to 10% annually.

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1.0 Introduction

The research to be presented focussed on the energy use in the administration complex of buildings, used by the Southern Downs Regional Council (SDRC) in Warwick Queensland. The SDRC was created via the amalgamation of the Stanthorpe and Warwick Shire Councils in March 2008. The Council serves about 30,000 residents and operates from two administration complexes, one located in Stanthorpe and the other in Warwick.

The project investigated the energy use and efficiency of the principal SDRC administrative operations in Warwick. The administration complex consists of five buildings, all of which are metered together for electricity:

- Administration Building
- Library
- Art Gallery/Tourist Information Centre (Gallery)
- Town Hall (includes offices and events hall)
- State Emergency Services (SES) building

There are also a number of overhead parking lights located in the car park that adjoins the buildings, and these are to be included in the audit as they connect to the main meter.

1.1 Background

1.1.1 Legislative

The reduction of carbon emissions is the key factor to mitigation of global climate change. Emission reduction can be effected in several ways: reduced energy consumption by users, increased energy efficiency in existing technologies, use of renewable energy. The management of energy equipment and its use plays an important role in ensuring that emissions are minimised, particularly in commercial buildings.

Energy management is increasingly important in Australia for economic reasons, as legislation requiring reporting on greenhouse gas (GHG) emissions takes effect. Specifically, the National Greenhouse Energy and Reporting Act 2007 (NGER Act) sets emissions thresholds above which businesses must report annually. The NGER Act sets out a national framework for reporting corporate energy use and greenhouse gas emissions. While SDRC is not currently required to report its emissions, the thresholds will decrease over time and in the future SDRC may have to report. It will be necessary to keep accurate records of all energy use, so that emissions may be calculated.

One of the major objectives of the NGER Act is to "underpin the introduction of an emissions trading scheme" (Dept of Climate Change, 2009). The probable introduction of an Emissions Trading Scheme (ETS) linked with the NGER Act will drive businesses, including Local Government, to minimise their GHG emissions in order to benefit from the reduced expense, and possible income, from the trade. By introducing energy efficiency measures and energy management into operations, councils such as SDRC may be able to reduce their liability for both emissions trading and reporting under the Federal legislation.

1.1.2 Potential benefits

There are many potential benefits of reducing energy consumption and emissions. First and foremost, money can be saved on energy costs. This is beneficial not only to Council, but to ratepayers, whose money is at stake in all Council expenditure. Many energy efficiency measures cost very little or no money to implement, and result in savings. In addition to the savings that may be realised in reducing energy consumption, those monetary savings may be used for other projects in the local community. The projects might even involve funding further energy efficiency improvements. Besides saving money on energy expenditure, efficiency measures often also result in savings on maintenance and replacement of building services and appliances.

1.1.3 Example for community

Local Government has an opportunity to serve as an example to area businesses, of how energy efficiency and management can increase profitability. There is currently no energy management strategy in place for the SDRC. However a Sustainability Strategy is being developed, that may include an energy management plan. If such a plan were to be introduced and maintained over time, there could be economic benefits to the local community, wherein new businesses would be attracted to a profitable location. In addition, residents could also learn from actions that councils take. They may begin to adopt energy-saving measures in their own homes, not only to save money but to take some responsibility for the environment.

1.2 Purpose/objectives

According to the Australia/New Zealand Standard, AS/NZS 3598:2000 Energy Audits, energy audits or surveys are:

> investigations of energy use in a defined area or site. They enable an identification of energy use and costs, from which energy cost and consumption control measures can be implemented and reviewed (Standards Australia, 2000).

This is a definition that is common around the world, with the New Jersey Department of Environmental Protection defining an energy audit as:

> a detailed examination of a facility's energy uses and costs that generates recommendations to reduce those uses and costs by implementing equipment and operational changes (NJ Dept of Environmental Protection, 2006) .

The objective of the research presented, is to use a Level 1 energy audit to determine the energy consumption associated with a specific portion of Council operations. In auditing and analysing the use of energy in the selected Council operations, some progress can be made in identifying points of wastage or areas where efficiency can be improved.

With the identification opportunities for improvement, appropriate suggestions can be made that address the issue of reducing energy consumption, while at the same time offering benefits such as reduced operational and capital replacement costs. Additionally, SDRC may be able to postpone its obligations to report GHG emissions or even reduce or delay its liability for emissions, depending on what legislation is passed.

The research itself has the potential to serve as a starting point in the active stage of Council’s Sustainability Strategy. In gathering and analysing energy use data for the present research, an example may be set, showing the basic steps involved in auditing the energy use in Council operations on a larger scale, as well as indicating the ease with which some changes and savings may be made.

2.0 Site Description

2.1 Warwick and climate

The buildings analysed are located in Warwick in southeast Queensland, with Latitude 28.21° south, Longitude 152.1° east (Australian Bureau of Meteorology, climate, 2009). Warwick is located in Climate Zone 5, according to the Building Codes of Australia (BCA). This climate zone is described as warm temperate, with the following key characteristics:

> Low diurnal (day/night) temperature range near coast to high diurnal range inland. Four distinct seasons. Summer and winter can exceed human comfort range. Spring and autumn are ideal for human comfort. Mild winters with low humidity. Hot to very hot summers with moderate humidity (Commonwealth of Australia, 2008).

There is a Bureau of Meteorology (BoM) weather monitoring station located at Warwick. The monthly average high and low temperatures at Warwick are shown in Table 1.

Table 1: Monthly Average Temperatures for Warwick QLD
(Australian BoM, climate, 2009)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Ave. Max (°C)	30.0	29.5	27.9	25.1	21.3	18.6	18.0	19.8	23.6	26.0	27.2	29.3	24.7
Ave. Min (°C)	16.9	17.0	14.8	11.1	6.8	4.7	2.7	3.0	7.2	10.5	13.6	15.8	10.3

These data indicate a generally high diurnal temperature range, and that winters can be quite cold at times, depending on the westerly winds (see Appendix 3). The average temperatures give a diurnal range of 14.35°C when averaged over the year. The actual temperature ranges will certainly be greater than this at times, due to the use of mean values in the above values. The greatest diurnal range is experienced in winter in this location. Fourteen years of BoM data also indicate that Warwick has an annual rainfall of 669.0mm spread through the year, with the majority generally falling through the summer months. The wind roses produced by the BoM for Warwick indicate south-easterly breezes in summer and both south-easterly and westerly breezes in winter (Australian BoM, wind, 2009). These charts are presented in Appendix 3.

2.2 Building descriptions

2.2.1 Construction and orientation

Each of the buildings in the study is constructed of brick, excepting the Town Hall, which is made of local sandstone with a timber extension. Each building is essentially rectangular, and is oriented so that the major axes run north/south and east/west. External photographs and basic floor plans for each building are presented in Appendix 1.

2.2.2 Main uses and operational hours and occupancy

The Administration Building is operational during regular business hours; that is, from 8:00am to 5:00pm Monday to Friday, except public holidays. Staff may occupy parts of the building at almost any time, depending on workloads, meetings and after-hours emergencies. Cleaning staff attend the building weekdays for two hours outside business hours. During business hours, the approximate number of staff present is 80. The building is used to house offices, meeting rooms and customer service reception areas. It also includes storage areas and necessary amenities for those who use the building, including toilets, break rooms and kitchen facilities.

The Town Hall is open during business hours, as well as other times after hours or on weekends when public or private events are held there. The average occupancy of the building during regular hours is five to ten people, and may rise to 150 during large events in the hall. The building is home to an event hall, dressing rooms, reception areas, toilets, storage areas, a few offices and two kitchen areas.

The Tourist Information Centre is open seven days per week. The hours are Monday to Saturday, 9:00 am to 5:00 pm and Sunday, 9:00 am to 3:00 pm. Staff are present from 8:30 am each day, and cleaning is done during open hours. The Art Gallery is open Tuesday to Friday, 10:00 am to 4:00 pm, and Saturday and Sunday, 10:00am to 1:00 pm. One or two staff members are present from 8:00am weekdays. The average occupancy of the building during regular business hours is approximately 10 people, including members of the public. The Gallery portion is also used some evenings for art exhibits. The building is primarily used for public displays and also houses some office and storage areas.

The Library is open to the public six days per week. The hours are Monday to Wednesday, 10:00 am to 5:30 pm; Thursday, 10:00 am to 7:30 pm; and Saturday, 9:00 am to 12:00 pm. Staff are present from 8:00 am each day and cleaning staff are present six days per week for two hours outside of this. There is a meeting room available for use after hours as well, which may be used any evening up until 10:00 pm. The number of occupants varies. However there are generally four to six staff members present and on average 10 to 20 members of the public during the opening hours after 10:00 am. The building houses library rooms with printed documents and various other media, meeting rooms, an office, storage areas, a kitchen area and toilets.

The SES Building is vacant most of the time. It is used weekly for 3-hour meetings, as well as for one full weekend out of every three. The weekend use is approximately eight hours per day for two days. Additionally, the building is used when there are emergencies in the area. This use is irregular. The occupancy during meetings and training weekends is approximately 20 people. The building is mainly a storage area for vehicles and equipment, as well as having a small office, toilets, a kitchen area and a meeting area.

3.0 Literature Review

3.1 Theory of energy efficiency in commercial/government buildings

The International Energy Agency (IEA) has estimated that in most countries, up to 40% of energy use can be accounted for by buildings, both residential and commercial (Ecogeneration, 2009). Research has shown that demand side energy management and energy efficiency practices can greatly reduce both costs and energy consumption. The reduction in consumption leads to a decrease in GHG emissions, which reduces the impacts of global warming (CitySwitch, office, 2009). In addition to these benefits, energy efficiency is also moving into the mainstream because it reduces air pollutants, reduces dependence on fossil fuels, increases electrical grid reliability and reduces the need for capital investment in new power plants (USEPA, 2007).

In the current world and Australian contexts, reduction in GHG emissions is an important factor for all levels of government, including local Councils. According to a 2008 Climate Institute report, the Australian commercial sector has the opportunity to make energy savings of up to 70% (McLennan Magasanik Associates Pty Ltd, 2008). Meanwhile, the IEA estimates that about half of the international CO_2 abatement goal could be achieved using existing energy efficient technologies (Ecogeneration, 2009). In Australia, the existing building stock offers some very cost-effective opportunities to increase energy efficiency and reduce emissions (Dept of the Environment, Water, Heritage and the Arts, 2009).

Energy efficiency in commercial buildings is available in multiple areas. Overall, operation and maintenance (O&M) of energy-using systems is often a major cause of energy waste in the government and private commercial sectors. Good maintenance practices are a real resource because they can generate substantial energy savings. Not only does an O&M program aimed at energy efficiency have the potential to reduce energy costs by 5-20%, it can also reduce capital costs of equipment by prolonging the life of the equipment (US Dept of Energy, FEMP, 2009).

Energy efficiency can also be easily achieved in commercial buildings through educating staff members (CitySwitch, home, 2009). Education and participation by all users of a building are important aspects of any successful energy management program. Efficient energy consumption is achieved in various ways depending on the end use. Commercial building services can be separated into five main sections, each providing efficiency opportunities beyond education and O&M practices. These areas will each be discussed briefly below.

3.1.1 Lighting

Lighting often offers a major, if not the biggest, opportunity for energy savings in office buildings (US Dept of Energy, economics, 2009). According to the United States Department of Energy, the use of timers and automatic switching in commercial lighting can both reduce the amount of energy used and improve occupant comfort and productivity. In association with the use of day-lighting, lighting controls offer one of the best ways to reduce lighting energy consumption (US Dept of Energy, checklist, 2009). There are many types of lighting controls available, including various occupancy sensors, switches, dimmers and timers, as well as combinations (inter.Light, Inc, 2009).

Additionally, the amount of light can often be reduced or optimised based on the task in certain areas. Over-lighting can cause glare and discomfort, while wasting energy. Day-lighting, individual task lighting and light coloured walls and ceilings allow overhead lighting to levels to be reduced (US Dept of Energy, checklist, 2009). Care must be taken to provide shade controls for day-lit areas, to prevent solar glare and excessive heat gain through large windows. Over-lighting can sometimes be a result of dirty fixtures, indicating the importance of regular cleaning as part of an O&M regime. Reduced lighting levels and higher efficiency fixtures also have the effect of reducing Heating, Ventilation and Air Conditioning (HVAC) loads in building interiors.

3.1.2 Computing

There are several methods to achieving energy efficiency in computing and peripheral equipment, including printers, fax machines, copiers, scanners and multi-function devices that combine one or more of these. Efficiency comes from smart purchasing, clever set-up and informed users.

It is important to choose the most energy efficient machines when making purchases, particularly for a commercial environment where it is likely that many machines will be acquired simultaneously. A useful indicator of efficiency is the Energy Star label found on many office appliances. Energy Star is an international energy efficiency standard for electronic equipment, that has been adopted by many countries including Australia. When enabled, Energy Star reduces power consumption in compliant machines by reducing power use in standby mode and activating a sleep mode when the machine is not in use (Dept of the Environment, Water, Heritage and the Arts, 2005). The key is to make sure the Energy Star functions are enabled on each piece of equipment, or there will be no energy or cost benefits.

In addition to choosing Energy Star compliant appliances, it is important to choose equipment that is the right size and capacity for the job. If a large multi-function print/scan/copy machine is left idle for large amounts of time, it would likely be more energy and cost efficient to replace it with a smaller machine that uses less energy.

There are methods of setting up computer networks and servers that can reduce costs and power consumption while achieving the same information capacity. Examples include choosing modern server technology that is more energy efficient, or using virtualisation in networks and servers. Virtualisation allows one machine to host multiple operating systems, because they are "virtual" rather than existing in the hardware. Even with the use of multiple machines for back-up purposes, an array of say 16 servers could be reduced to four, while still supporting the same number of users and applications, and at the same time being secure and having real-time back-up (Ou, 2006).

User education can also result in reduced energy consumption. Switching off computers, screens and other equipment when not in use, is a habit that saves energy. Particularly over weekends and holiday periods, there is a large amount of energy wasted by this equipment. During these times, and overnight if practical, computer equipment should be switched off at the wall to prevent standby power being consumed. Another benefit of switching off equipment when not in use is that HVAC loads are reduced. According to the Illuminating Engineers Society (IES), every 2 to 3 kW of lighting load requires an additional kilowatt of cooling, so that theoretically, a 1 kW reduction in lighting can reduce the total energy consumption by 1.3 to 1.5 kW (Tri-State Generation and Transmission Association, Inc, 2000).

3.1.3 HVAC

Heating, ventilation and air conditioning (HVAC) systems can account for up to 70% of energy use in a commercial building, according to the Department of the Environment, Water, Heritage and the Arts (Dept of the Environment, Water, Heritage and the Arts, 2009). There are many ways to increase the efficiency of these systems, thereby reducing consumption and costs. An important option is to use timers and controllers to ensure that temperatures are kept within specified ranges and that the system does not operate outside of the operational hours of the building (Dept of the Environment, Water, Heritage and the Arts, 2009). Zoning is also an important inclusion, which allows different rooms or areas of a building to hold different temperatures. This is important particularly where there are sunny windows in some rooms or for areas that have sporadic occupancy.

Regular and thorough maintenance is also an important factor in optimising the energy efficiency of HVAC systems. This allows for identification of problems before they become major, as well as ensuring that the plant operates at its optimal output. As an example, valves and filters should be checked regularly to make sure nothing is stuck open or closed, and that filters are clean so that the system does not have to work hard to compensate for reduced air flow (Dept of the Environment, Water, Heritage and the Arts, 2009).

3.1.4 Domestic Hot water

The heating of water in commercial buildings is a relatively minor energy end-use, particularly when compared to HVAC systems. According to the Australian Greenhouse Office, the typical percentage of energy use from cooking and hot water combined in a commercial building in 1990 in Australia was 6% (Australian Greenhouse Office, 1999). Regardless of the low proportion, there are important and often simple ways to improve the efficiency of water heating in buildings.

Commercial buildings often provide boiling water units and electric urns for staff amenity. These units can be made more efficient with the use of timers so that they do not operate overnight or on weekends, as well as with optimal sizing of the units themselves. A unit that is too large for the number of users will waste heating energy.

Timers and proper sizing are also important for use on larger hot water systems (HWS) of all types. Storage HWS's also benefit from the installation of blankets or insulating materials around the tanks. This is especially important in situations where the unit is located outside or in a draughty area. All types of HWS's can be improved by insulating the pipes that lead to and from the units, to minimise heat losses. Temperature settings may be adjusted to reduce the energy consumption, particularly in settings where the main uses exclude food preparation and dishwashing. This applies to many office buildings, where hot water is used primarily for hand washing.

Aside from optimising existing HWS's, there is also the option of replacing or upgrading the system to reduce energy consumption. Some options are on-demand electric hot water units, where the water is heated when the tap is opened. This reduces heating energy because the unit does not need to have hot water on stand-by at all times. Another option is solar water heating. These units are widely available and are proven to be commercially viable. These units come in various sizes and may have an electric or gas back-up booster so that there is no shortage of hot water regardless of the weather or time of day.

3.1.5 Building envelope

The physical characteristics of a building can have a profound effect on its energy performance. The Australian Government's "Your Home Technical Manual" provides several important methods of optimising energy efficiency in residential buildings (Commonwealth of Australia, 2008). However, these design principles apply equally as well to commercial buildings.

The first and foremost design principle for efficiency is orientation with respect to the sun. Correct orientation allows for passive heating and cooling, which can save a large amount of energy expenditure during the life of the building, while increasing occupant comfort (Commonwealth of Australia, 2008).

The other important design principles that impact on energy efficiency in buildings are the type of glazing installed and the shading of the glass. Suitable glazing is essential to reduce heat loss and gain through the windows: summer heat gain can be up to 100 times, and winter heat loss can be up to 10 times, greater through a window than through the same area of insulated wall. There are many types of glazing available, including tinted, reflective, low emissivity and double- or triple-glazing. The best type of glazing for a building depends on the climate, the building layout and the size and location of the windows (Commonwealth of Australia, 2008).

Shading of a building and its windows aides in reducing summer indoor temperatures, and thereby saves on mechanical cooling. Shading can block up to 90% of direct solar heat gain through windows. As with glazing, the type of shading depends on the climate and the orientation of the area to be shaded. Shading can be positioned indoors or out, may be adjustable or fixed, and may also include plants and trees. In areas where winter heating is required, it is important to position shading devices so that winter sun is not blocked (Commonwealth of Australia, 2008).

The insulation of walls, ceilings and even under floors is a key means of improving building performance, due to the minimisation of heat loss and gain through the building envelope. The value of insulation is in its ability to minimise the variation in indoor temperature, despite high diurnal variations outside. There are numerous types of insulation, that suit any construction materials. The choice of what type and how much to install depend on the climate as well as preference and budget. Insulation is best installed at construction of a building, but can also be retrofitted in many situations. The most economical time to retrofit insulation is during a renovation. The use of insulation in commercial buildings has the important effect of reducing the load on HVAC systems, particularly in areas where heating and/or cooling are important (Commonwealth of Australia, 2008).

3.2 Case Studies

3.2.1 Australian Local Government case studies

Cities for Climate Protection (CCP) is an international program under which member local governments make commitments to reduce GHG emissions. According to the 2008 CCP Australia Measures Evaluation Report, there are numerous local governments across Australia implementing energy efficiency measures in order to reduce GHG emissions (Dept of the Environment, Water, Heritage and the Arts, 2008). Many of the actions taken by local governments in the quest to reduce emissions also improve the energy efficiency of their buildings.

Recent building-related energy efficiency measures undertaken by Australian local governments cover the whole range of building efficiency sectors. In the area of information technology, measures include: providing energy-efficient computers and monitors to all staff; replacing network servers with more efficient models or with virtual server technology; implementing staff programs to encourage switching off of computers and monitors; and enabling Energy Star features on laptops and other office equipment (Dept of the Environment, Water, Heritage and the Arts, 2008).

Lighting efficiency has been addressed in the following ways: installing energy-efficient lighting at council facilities; installing voltage-reduction controls for lighting in offices; removing lights in low-use areas; and installing timers and sensors on office lighting (Dept of the Environment, Water, Heritage and the Arts, 2008).

Councils are optimising the efficiency of HVAC systems by tuning air conditioning units to reduce wastage and time of use and reducing the temperature range within which heating or cooling are required (Dept of the Environment, Water, Heritage and the Arts, 2008). The amount of energy that can be saved through improving HVAC systems is substantial, as these systems typically account for up to 70% of consumption in commercial buildings (Dept of the Environment, Water, Heritage and the Arts, 2009).

Many councils have adopted organisational measures and procedures to assist in reducing consumption and emissions. These range from staff education programs to purchasing strategies to the installation of solar panels on buildings. Some examples include the development of green purchasing and procurement strategies, implementation of energy performance contracts, the purchase of various proportions of Green Power, the development of web-based learnings to teach staff of the environmental effects of office practices and provision of staff training on sustainable purchasing. In addition to these, councils have installed timers on existing hot water systems, upgraded to solar hot water, undertaken energy audits and implemented energy saving measures identified in the audits (Dept of the Environment, Water, Heritage and the Arts, 2008).

While information on costs and benefits of the measures that local governments are taking is not readily available, it is important that the measures are being taken at all.

Many of the actions stated above involve very little or no capital investment and these are the logical first steps for any organisation to take when attempting to reduce energy consumption and GHG emissions. The more complex and costly actions can often be scheduled to coincide with maintenance or upgrades, and may also be funded in part by savings gained from the initial actions taken.

3.2.2 Australian Commercial case studies

Not only local government buildings, but commercial and all levels of government buildings, including retail and offices, can benefit from the introduction of energy efficiency measures. In Australia, many companies from coast to coast are taking action with impressive results in cost savings, energy savings, or both. Three examples are described below. In this and all sections, where dollar amounts are quoted, they are in Australian dollars unless otherwise noted.

In Melbourne, Treasury Place implemented lighting upgrades in two buildings with great results. Some of the measures introduced include the installation of a lighting control system; installation of occupancy sensors in meeting rooms; a decrease in the automatic lighting hours by a half hour per day; and the selective removal of fluorescent tubes where suitable. In addition, cleaners were involved in ensuring that all enclosed office and meeting spaces were switched off after cleaning. The results of the upgrade, which took place over approximately three years, were a reduction in overall energy consumption by 15% and cost savings of almost $75,000 per year (Dept of the Environment, Water, Heritage and the Arts, 2009).

On a much larger scale, Centrelink has an environmental policy to conduct operations in an environmentally responsible manner. This extends to all of its facilities across

Australia. The energy-efficiency of Centrelink's buildings was improved over the two years to 2006, with an overall reduction in energy consumption of 7%, or 37,000 Gigajoules. The GHG emissions were also reduced by 7% during that time, through both building and fleet efficiency. Specific measures that Centrelink implemented include the use of energy audits on over 200 offices and adoption of some of the recommendations; the introduction of "Lights Off" campaigns encouraging staff to switch off; and the widespread purchasing of appliances that have Energy Star ratings, including desktop computers and screens, multifunction devices and kitchen appliances. Centrelink acknowledges that staff commitment is a critical part of the success of its programs. Staff are involved in many ways, including through training, web-based learning modules and a network of volunteer environmental champions to act as role models (Dept of the Environment, Water, Heritage and the Arts, 2009).

In Perth, the QV1 Tower owners and tenants took an increasingly common approach to building energy efficiency. The building service manager is responsible for base building upgrades and maintenance, while each tenant is responsible for any energy efficiency improvements within its own space. Notably, a sustainability committee was established in 2007 with members from both building management and tenancies. With this arrangement, many tenants have undertaken lighting improvements to meet their needs and goals, and the base building achieved a 4 star NABERS Energy rating in 2005 (out of 5 stars). Car park lighting energy has been reduced by 30% with the installation of Ecolights, and all common lighting is reduced to half after hours. Additionally, lift lighting has been changed from incandescent to compact fluorescent (CFL) globes with a resultant saving of $13,000 per year. The project is ongoing, but one tenant, PwC, has reported a 16% return on their lighting investment of \$25.70/m^2 (Dept of the Environment, Water, Heritage and the Arts, 2009).

3.2.3 International case studies

Many organisations around the world are getting involved in increasing energy efficiency in order to reduce emissions and costs. The fact that the international business world is participating in these activities indicates that there is truly money to be saved and possibly made. Three examples are described below.

Kolter Property Management Limited in Toronto Canada is a large real estate developer. In five properties at Canada Square, one of Kolter's major property locations, many energy retrofits were undertaken. These include upgrading lighting systems with electronic ballasts, light reflector systems and efficient T8 lamps; new and upgraded HVAC control systems; sub-metering of electricity; energy monitoring and tracking; and staff education. The project saw retrofits in a total area of nearly 90,000m^2, and cost approximately $1.25 million Canadian dollars. The savings were expected to be almost 20% of energy consumption and just over 17% of energy costs per year. The leaders at Kolter say that the focus on and investment in energy efficiency is saving the company money, and that the upgrades have improved the working conditions inside the buildings (Natural Resources Canada, 2004).

In New York City, the owners of the Empire State Building, along with several project partners, announced a plan in April 2009 to reduce the energy consumption of the building by 38%, thereby saving $4.4 million USD annually. Although the project has not yet been completed, the plan was the result of a 12 month study by several experts. The retrofits and upgrades include works on the chillers, windows and seals, corridor lighting and tenant lighting. Notably, these works were made more economical because they will coincide with scheduled upgrades or replacements. Additionally, over half of the energy savings will result from measures that involve some level of engagement with the tenants of the building. This was seen as an important step in capturing the full amount of available savings by the project team (Maurer & Deshmukh, 2009).

In Stuttgart Germany an old school was retrofitted and renovated in 1996-97 to reduce the energy consumption of the building while optimising the economy of the retrofit. The school had been built in several stages over the years and thus had varying types of building characteristics. Some of the actions taken were insulating the walls of the buildings and the gymnasium roof; replacing windows with modern glazing types and new frames; replacing the lighting system and adding a control system; and a complete renovation of the HVAC system, including zoning and tamper-proof thermostats. Several sensors were installed in the buildings to monitor the results, and after two years, the average energy consumption per square metre was shown to have been reduced by more than half (ManagEnergy, 2009).

3.3 Energy Auditing and Energy Reporting Obligations in Australia

3.3.1 Energy Audits in Australia

The procedures and inclusions of an energy audit carried out in Australia are outlined in the Australia/New Zealand Standard, AS/NZS 3598:2000 Energy Audits. According to the standard, energy audits or surveys are:

> investigations of energy use in a defined area or site. They enable an identification of energy use and costs, from which energy cost and consumption control measures can be implemented and reviewed (Standards Australia, 2000).

The standard indicates three types of energy audits, with various levels of inputs and corresponding depth of results. A Level 1 audit is the most basic, and may consist of only a desktop study of a site, allowing energy benchmarks to be determined for further tracking. This type of audit also returns the roughest estimates of costs and savings associated with energy efficiency measures. A Level 2 audit requires more detailed input information, such as the sources of energy, what it is used for, and how much energy is supplied to the site. Recommendations are made on energy efficiency measures, and the cost and savings estimates are more accurate than in a Level 1 audit. A Level 3 audit is the most detailed and accurate type of audit identified in the standard, with firm estimates of costs and savings (Standards Australia, 2000).

The standard identifies certain requirements for all levels of audit, regardless of the depth of the investigation. These requirements are an examination of the energy sources and consumption of the site; a consideration of site services and building fabric; a consideration of the site's use and occupancy; an analysis of energy performance in relation to the site's size, location and use; a review of any site energy management policy or procedures; and the identification and recommendation of energy and financial savings measures for the site (Standards Australia, 2000).

In addition to these requirements, a Level 1 audit has certain specific requirements, as follow. The total consumption of all fuels for the site must be determined for the 24 months prior to the audit. Should these data not be available, estimates based on installed loads may be used. An evaluation of any available load profile data must be included, and a monthly or seasonal energy consumption profile for each fuel must be prepared. A tariff analysis of all forms of energy on the site should be included, if the analysis does not involve excessive research and reporting. The audit must identify potential areas for reduction in costs and energy use, and should recommend further actions to achieve these reductions. (Standards Australia, 2000).

A Level 1 energy audit is essentially a desk-top analysis of a site's energy use, in order to identify trends in use; energy service options and tariffs; and any errors that may have occurred in the billing. Perhaps most important in the long term, the historical audit provides a baseline against which the effectiveness of any implemented energy savings methods can be measured in the future. This type of energy audit can often be done in-house and may generate savings with little or no capital outlay.

In addition to the desk-top review, Level 2 and 3 energy audits includes an active data-gathering portion. The research presented herein incorporated a walk-through type audit for each building, but not to the extent of a full Level 2 audit. The Level 2 and 3 audits include an examination of the building and its associated energy systems and major appliances. In tandem with the historical data, a list of all saving options can be generated, with a greater level of detail and accuracy than a Level 1 audit offers (Standards Australia, 2000).

3.3.2 Energy Reporting in Australia

The National Greenhouse Energy and Reporting Act 2007 (NGER Act) is a piece of Federal legislation that sets emissions thresholds above which businesses must report annually. The NGER Act sets out a national framework for reporting corporate energy use and greenhouse gas emissions. A major objective of the NGER Act is to lay the foundation of an Emissions Trading Scheme (ETS), with an aim to drive businesses to minimise their GHG emissions in order to benefit from the reduced expense, and possible income, from the trade.

The NGERS requirement to report energy use and GHG emissions is based upon a corporation or any of its facilities exceeding specified thresholds of either energy use or emissions in a financial year. The first reporting year was 1 July 2008 to 30 June 2009. A business must report both its energy use and GHG emissions for each year during which it meets a threshold, regardless of whether it meets an energy or emissions threshold (Dept of Climate Change, 2009).

There are NGERS thresholds for both facilities and for entire corporations. These thresholds decrease each year for the first three reporting years. In this way the legislation will over time capture more of the large energy users in the reporting mechanism. This will allow Australia's annual energy use and GHG emissions to be more accurately reported to international bodies. The reporting thresholds for the first three years are as follow in Table 2.

Table 2: NGERS Reporting Thresholds (Dept of Climate Change, 2009)

	2008-2009		2009-2010		2010-2011	
	Energy Use	Emissions	Energy Use	Emissions	Energy Use	Emissions
Facility	100TJ	25kt	100TJ	25kt	100TJ	25kt
Corporation	500TJ	125kt	350TJ	87.5kt	200TJ	50kt

3.3.3 Australian Building Energy Rating

The National Australian Built Environment Rating System (NABERS) is a web-based system that is used to rate existing buildings on various environmental impacts including energy use, water use, waste produced and indoor air quality. The system is supported by the New South Wales Department of Environment, Climate Change and Water (NABERS, 2008), and can be used to rate residential, commercial, retail and hotel buildings.

The rating of a building allows building users to compare their building performance with that of other buildings of the same type around Australia, regardless of size or location. The inputs for an energy assessment of commercial buildings (NABERS Office) in particular, include the location, floor area in square metres, number of people, number of computers, hours of operation and annual energy use. The assessment may be done on a whole building (owner/occupier), tenancy or base building, depending on how the building operates and who wants the rating (NABERS, 2008).

The results of a NABERS Office Energy rating indicate the energy use per square metre per year, the energy use per person per year and a star rating out of five stars. The star rating takes into account the location and size of the building so that comparisons may be made between any office buildings. The result offers the users of a building an indication of how well the building performs compared to other buildings of the same type, and may serve as a starting point in energy management planning as well as in decision making about whether to perform an energy audit on the building (NABERS, 2008).

4.0 Methods

4.1 Level 1 energy audit

4.1.1 Historical data review

The SDRC does not have an energy management officer or other similar role defined in its structure. Historical energy accounts had to be sourced from the Finance Department, by searching through all invoice payments made by the Council. The software used to track payments only keeps records for approximately 12 months; for this reason the historical data used in the present research only includes from April 2009 back to March 2008. Older data is on file physically, yet the time involved in locating individual invoices paid was prohibitive.

The monthly electricity accounts located contain information on the tariffs, fixed charges, maximum demand and charges, time of maximum demand and load factor. The service contract also provided clarification on the types of charges, the length of the agreement and the calculation of the tariffs.

4.1.2 Walk-through audits

Walk-through energy audits were performed in each of the buildings during the period from 10 March 2009 to 9 July 2009. The Facilities Maintenance Officer (FMO) assisted in giving details on time of use, gathering equipment power specifications and generally locating all pieces of energy using equipment. In addition, he provided information regarding the physical construction of the buildings.

Excepting the administration building, the audits were all carried out during business hours, so that general daily use could be ascertained. Due to the higher occupancy and the important and sometimes sensitive nature of the business activities carried out in the Administration building, the audit was done after hours for this building. This presented a limitation in the accuracy of the usage data, as estimates are likely to have been 'rougher' without the benefit of user input. Additionally for the administration building, walk-through monitoring was done on the state of computers and screens after hours. These audits were done separately from the primary energy audit, and the purpose was to determine the proportion of users that regularly turn off computers and screens overnight and on weekends.

In conjunction with the walk-through energy audits, information was sought from the Information Technology (IT) department on numbers, types and power specifications and settings for all office equipment. This equipment includes network servers, telephones, desktop and laptop computers, screens, network copiers, printers and multifunction devices and the City Safe camera equipment.

Using the information gathered in each building walk-through audit, the lighting power density was calculated. This was done by summing all of the lighting wattages in a building and then dividing the result by the area of the building in square metres. The lighting power density is the result, with the unit of kilowatts per square metre, or kW/m^2.

4.2 Use of literature and case studies

The literature shows that there is a broad range of opportunities for commercial buildings in general to reduce energy consumption. The documented experiences of local, national and international businesses and governments also uphold the research claims. In performing the walk-through audits of the SDRC buildings and while analysing the historical consumption data, it was important to note similarities between the case being studied and the documentation relating to energy efficiency. Relevant efficiency measures or cost-saving opportunities from the literature were noted for possible implementation in the operations of the SDRC.

4.3 NABERS Assessment of Administration Building

The NABERS Office Energy rating tool was used on the Administration building, in order to get a basic idea of how well the building operates. Only the Administration building was assessed using NABERS because the other buildings have primary uses other than office space. Only the Energy rating tool was used on the building due to the limited nature of the audit. Additionally, the Whole Building was rated, since the SDRC both owns and occupies the space. Aside from the location of the Administration building, the key inputs as outlined in section 3.3.3 were gathered during the walk-through audit of the building.

5.0 Results

5.1 Historical data review

The SDRC is a party to a current service agreement with an electricity retailer, which lasts until the end of 2010. Confidentiality clauses contained within the agreement require that among other information, the charges must also be treated as confidential. For this reason, neither the name of the retailer nor the exact charges will be disclosed here.

A review of the electricity accounts shows that the SDRC paid just over $77,000.00 for 574 Megawatt-hours (MWh) at this site, during the 12 month period from March 2008 to February 2009. This includes several types of charges, which are described in the service agreement. These charges include various demand charges based on the peak demand for each month; consumption charges for peak and off-peak usage and for overall usage; and fixed network, metering and Community Ambulance Cover charges. The approximate proportional breakdown of the charges is shown in Table 3.

Table 3: General proportions of different types of charges under retail service agreement, based on SDRC accounts for 14 months.

Charge Type	**Average Proportion**
Fixed	10%
Consumption Based	60%
Peak Demand Based	30%

It is important to note that should there be a change in total consumption, peak demand or peak vs. off-peak consumption, the proportions in Table 3 could change. Under the service agreement, the retailer must be notified in advance of any anticipated change in the total consumption greater than a certain percentage.

As shown above, the tariff consists of both per-kWh charges and peak demand charges each month. The per-kWh charges are split between peak and off-peak periods. The peak period is from 7:00am-11:00pm Australian Eastern Standard Time, each day except weekends and public holidays in Queensland. The off-peak period is all other times. It is important to note that the times indicated are in Standard Time, as Queensland does not adopt Daylight Savings Time. This is unlikely to have a large impact, but should the SDRC decide to shift energy consumption to off-peak periods, this would need to be considered.

The accounts show that in the 12 months from March 2008 to February 2009, the complex of buildings had an energy consumption of 574MWh. There are seasonal variations in the daily consumption, as would be expected due to changes in weather and temperature. The profile for this period is shown in Figure 1.

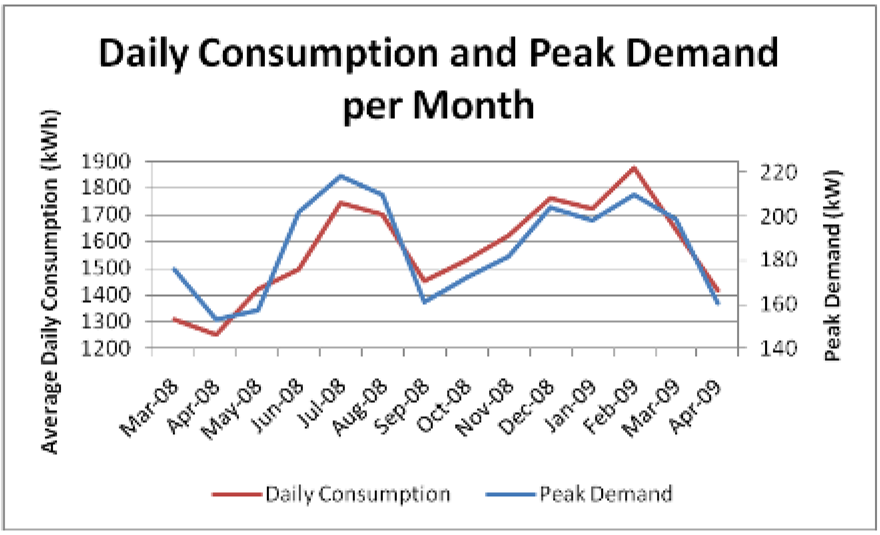

Figure 1: Daily consumption and Peak demand per month, based on 14 months of energy accounts. They follow a similar seasonal pattern. Note that the July peak includes heating and the February peak includes cooling.

Figure 1 also shows the peak electricity demand per month, with a similarly shaped trend. As with the daily consumption there are two peaks in winter and summer;

however their relative size has changed. This may be due to the coincidence in winter of the heating system working hard at the beginning of the day when all of the office equipment is also starting up. While in summer the overall consumption is higher, the times of high demand are spread through the day whereas in winter the greatest demand from different types of equipment occur simultaneously. This is shown in Figure 2.

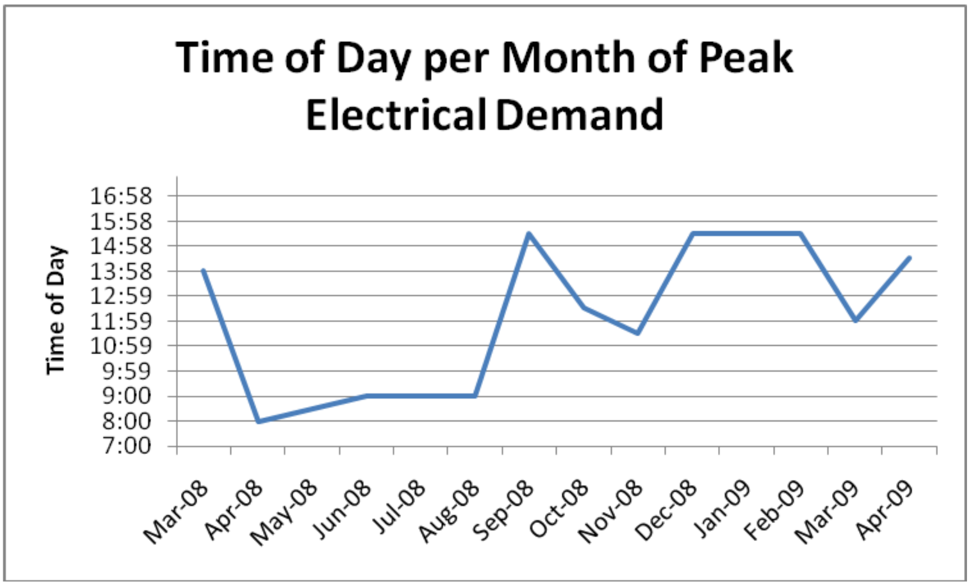

Figure 2: The peak demand occurs at the start of the business day during winter and generally after lunch or later in the afternoon during other seasons. Note that April 2009 indicates a change in the possible trend.

A typical load profile for the complex was not available for analysis. However, it is clear from Figure 2 that there would be a morning peak during winter, and generally an afternoon peak in summer, spring and autumn. Actual data would help should SDRC look into reducing peak demands by spreading loads through the day.

Sub-metering is not in place for this complex of buildings. This causes difficulty in determining the relative contribution to energy consumption and demand for each building. Therefore there is no historical data relating to the relative proportions of energy use from each facility.

5.2 Walk-through audits

The audit of the administration building comprised of two sessions of checking equipment, two after-hours audits of computer status and requesting and gaining information from the IT staff about office equipment and operational settings. The other building audits were each carried out in a single session during business hours.

The walk-through audits allowed for several observations to be made. The following apply to all buildings. All exterior lighting is automated using either daylight sensors or timers (6:00pm-6:00am), while all interior lighting is manually operated by users. With a few noted exceptions, all of the HVAC units in the buildings are operated automatically using timers, which are set to run from 7:00am to 5:00pm daily. Filters are checked and cleaned by the FMO, generally only when the alarm on the units sound. Neither timers nor insulation have been installed on any of the HWS's in the buildings. Other observations made during the walk-through audits are presented in Table 4 on the following pages.

Table 4: Observations made during walk-through audits

Facility	Building	Lighting	HVAC	Appliances	Hot Water
Administration	• Constructed c. 1960, extended 1998 • 2 storey, brick, flat roof • Tinted southern glazing • Fixed exterior shading on north & south windows • Zoning – most offices on north side • Few windows east & west	• Interior: fluorescent, CFL, halogen • Switch for each enclosed room; 1 or more for shared spaces • Kitchen & toilets switched on all day • Cleaners ensure all is off by 9:00pm • Elevator light on all the time • Exterior: fluorescent, CFL, metal halide, halogen • Used for security and signage	• 2 large units for new section; 1 storey each, use zoning • 2 small units in server room, operate all the time • 13 other small units for various offices, meeting rooms and shared spaces • Windows do not open; doors are weighted or close automatically • Ventilation only from HVAC units	• Most office equipment left on overnight and weekends • Many appliances revert to sleep or standby modes • 83 computers and monitors, including laptops • 66% of monitors left on overnight and weekends • 13% of computers left on overnight and weekends • Virtually nothing switched off at wall	• 2 storage units, 80L & 50L • Housed in a closet and under a sink, avoiding draughts
Town Hall	• Constructed c.1888, extended 1911 • Sandstone block with timber extension, metal roof uninsulated • 2 storey with double-storey hall	• Interior: fluorescent, incandescent • Most lighting in hall, e.g. stage lights • Sporadic use of hall, event foyer, stage & backstage lights Public toilet lights on	• 2 large units for events hall; manual operation with timer as user pays • 1 unit for CitySafe security room & Youth Services office, operates all the time	• Office equipment other than computers left on overnight and weekends • CitySafe camera equipment on all the time	• 2 storage units, 50L & 125L • 1 housed under building, un-conditioned area • 1 housed outside, exposed to wind

Facility	Building	Lighting	HVAC	Appliances	Hot Water
Town Hall	• No insulation or HVAC in extension • Hall glazing blacked out, office glazing shaded by neighbouring buildings	all day • Exterior: mercury vapour, metal halide, incandescent • Used for security, footpath lighting & clock tower	• 5 other small units for offices & foyer	• Hall audio system only on during events • Large display refrigerator in events foyer always on despite rare use	
Art Gallery	• Constructed 1998 • Brick with stylised roof • South facade nearly fully glazed, north side very little glazing • Public areas on south; storage, meeting & office areas on north	• Interior: fluorescent, CFL, metal halide, incandescent • Most lighting in art display areas, variable time of use • All halogen in Tourism public area • Lights in 2 storage areas left on all day regardless of occupancy • Exterior: metal halide, mercury vapour, CFL • Used for security; some on 24 hours	• 2 ducted units • 1 for Gallery & 1 for Tourism centre	• Computers shut down overnight & weekends • Equipment such as printers etc left on at all times • Sound system amplifier left on all the time despite infrequent use • Water feature outside near entrance; pump on 24 hours because no switch and outlet is inside a locked box	• Single 50L unit under sink
Library	• Constructed c. 1960's, extended 1998 • Brick, single storey,	• Interior: mercury vapour, fluorescent, halogen • Halogens only for	• 2 ducted units for newer section • 5 small wall-mounted units for	• Public-use office equipment switched on 2 hours before open to	• Single 25L unit under sink

Facility	Building	Lighting	HVAC	Appliances	Hot Water
Library	with flat roof • North & south facades heavily glazed with interior and exterior shading • Skylight located in main book room is not very effective	accent, but nothing to display • Most lighting switched on 2 hours before open to public • Exterior: mercury vapour, CFL, incandescent, fluorescent • Used for security, signage & garden	older section as no ceiling space for ducting	public • All computers switched off overnight & weekends • Entertainment appliances used near-continually during business hours to test media for hire • Small water feature inside, pump on 24 hours because no switch and outlet is inaccessible	
SES	• Constructed pre-1990's (no documentation) • Brick, single storey with flat roof • Bound by car park on north & west • 3 windows, all with interior blinds • Open plan except office & toilets enclosed	• Interior: fluorescent & incandescent • All fluorescents on a single switch, so all on during occupancy • Exterior: halogen • Used during weekly meetings for outdoor exercises	• Single unit • Operated fully manually due to infrequent occupancy	• 2 computers, fax & multifunction device • Refrigerator, stove, urn & 2 fans • All switched off except refrigerator	• Single LPG unit • Very low usage, so consumption ignored

Facility	Building	Lighting	HVAC	Appliances	Hot Water
Car Park Lighting	N/A	• 6 mercury vapour overhead globes • Operate 10 hours per day • 125W each, leading to 2.8MWh per year Manual override switch located beneath Town Hall	N/A	N/A	N/A

With the help of assumptions about time of use and information provided by the FMO, an estimate of the total annual energy consumption of the SDRC Administration complex was made. The total energy use is estimated to be approximately 870MWh per year. This includes all internal and external lighting, HVAC plant, kitchen and office appliances and water heating equipment. The data gathered and used in the audits is presented in a spreadsheet format in Appendix 4, on the accompanying CD.

6.0 Interpretation

6.1 Historical data review results

6.1.1 Seasonal pattern

The data from 14 months of electricity accounts indicate that daily consumption peaks both during summer and winter. Due to the seasonal weather pattern and change in temperatures, this is a logical outcome. The need for air conditioning during both seasons, combined with the low consumption during spring and autumn, suggests that HVAC may be the major end use for energy in this complex of buildings. There is no major seasonal aspect to the operations of any of the buildings.

The daily consumption and peak demand in both March and April 2009 have increased upon the values from March and April 2008. This may or may not represent a trend; further comment would require more data. In order to get a more accurate view of the energy use, further monitoring of accounts is required, and sub-metering would greatly clarify the situation.

6.1.2 Appropriateness of tariff agreement

The tariff agreement to which SDRC is a party is valid through 2010. It is appropriate to evaluate any changes to the agreement that may benefit the council should they be negotiable. One such change may be the time of peak and off-peak classifications. Currently the off-peak hours run from 11:00pm to 7:00am Monday through Friday and all weekends and public holidays. Should the off-peak start time be moved forward to 8:00pm, savings could be made on essential power use such as car park lighting, computer servers and security equipment.

There are some options to explore that may reduce the cost of energy under the current tariff. First, the consumption based charges account for approximately 60% of the total cost each month. Reduction in actual consumption is an important opportunity to analyse. As an example, perhaps the simplest way to reduce loads overall would be to educate staff and ensure that all unneeded lighting and equipment is switched off. After overall reduction, the shifting of loads to off-peak times should be evaluated. The off-peak charges are just under half of the peak charges, so even using the same amount of energy at a different time could save the council over 50% on that portion of the account. The peak demand charges generally account for approximately 30% of the electricity account. There is room for a reduction in these charges, by scheduling certain tasks or operations at different times. As an example, the heating systems in winter could be set to start up one hour earlier than at present so that it would not coincide with users arriving and switching on lighting, computers and powering up other equipment at the start of the day.

6.2 Walk-through results

The usefulness of the historical data was optimised by comparison with the results from the walk-through audits. The information gathered from the individual buildings allowed for a clearer view of the energy consumption pattern for the site. Each building has its own occupancy rate and schedule, as well as varying uses including offices, artwork display and public and private functions. The walk-through audits gave some insight, albeit rough, into the proportion of energy used by each building. This was important due to the lack of sub-metering of the buildings.

6.2.1 Total energy use

The walk-through audits indicate that approximately 870MWh would be consumed in an average year – compared to a measured value of 574MWh. This total was calculated using the estimated times of use for each appliance, and multiplying that time by the measured or calculated power rating of the appliance. Neither the actual energy use of

574MWh nor the estimated energy use of 870MWh meets any facility threshold for reporting under NGERS legislation. It is uncertain whether the SDRC as an entire corporation meets a threshold; however this falls outside the scope of the current research. In any case, SDRC has not made any report as yet under NGERS.

6.2.2 Proportions by building

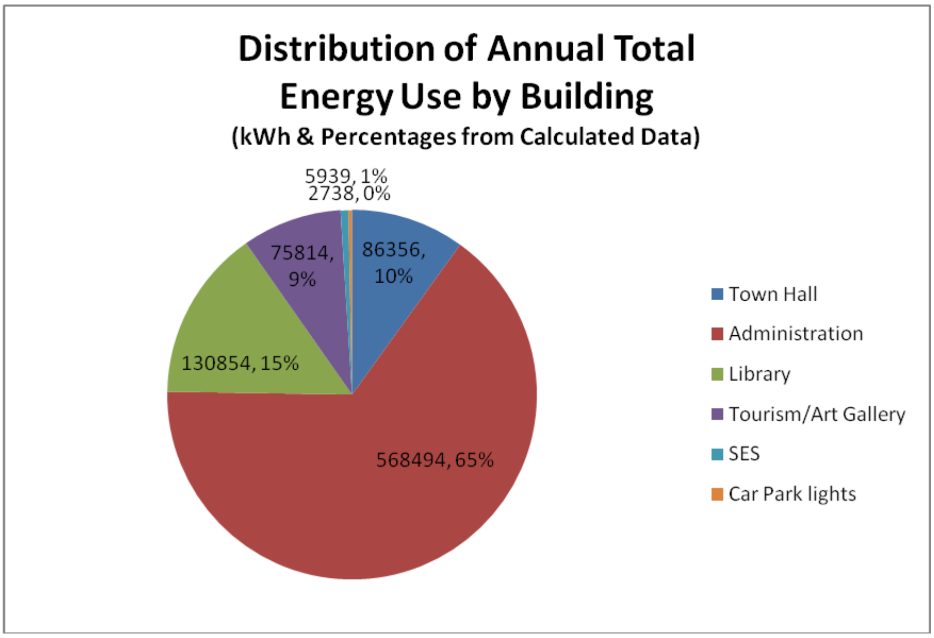

Figure 3: Walk-through audit data showing total annual energy use distribution by building. All gathered energy data were used to compile the result.

The proportions of energy use by building, calculated from the audit results, do not present any great surprises. These results are presented in Figure 3. The Administration building is the largest building with the largest occupancy and the greatest number of electrical appliances, so it stands to reason that the results show it to be the largest consumer of the five buildings. Similarly, the SES building is relatively rarely used, is very small and has comparably fewer appliances. This should logically be, and was estimated to be, the building with the lowest total energy consumption.

Table 5: Calculated interior lighting power density of each building

Building	Lighting Power Density (kW/m^2)
Administration Building	13.0
Town Hall	139.8
Art Gallery/Tourist Information Centre	13.9
Library	10.9
SES Building	6.3

The interior lighting power densities of the buildings (Table 5) were in some ways expected, while there were also some slight surprises. The fact that the Town Hall has the largest density is logical when the stage lighting is taken into account. The Gallery could reasonably have a similarly large density. However the extensive use of efficient lighting including CFL's and fluorescent lights assists in reducing the overall density by a great deal. The Administration building is similar to the Gallery, possibly because of the reception areas and the existence of near-uniform lighting throughout all work areas and corridors. The result that the Library has a lower density than the Administration building is slightly surprising because of the need for adequate reading light. However, the Library takes advantage of natural light in its reading rooms as well as in the main book room, so this could be a partial explanation.

6.2.3 Proportions by end use

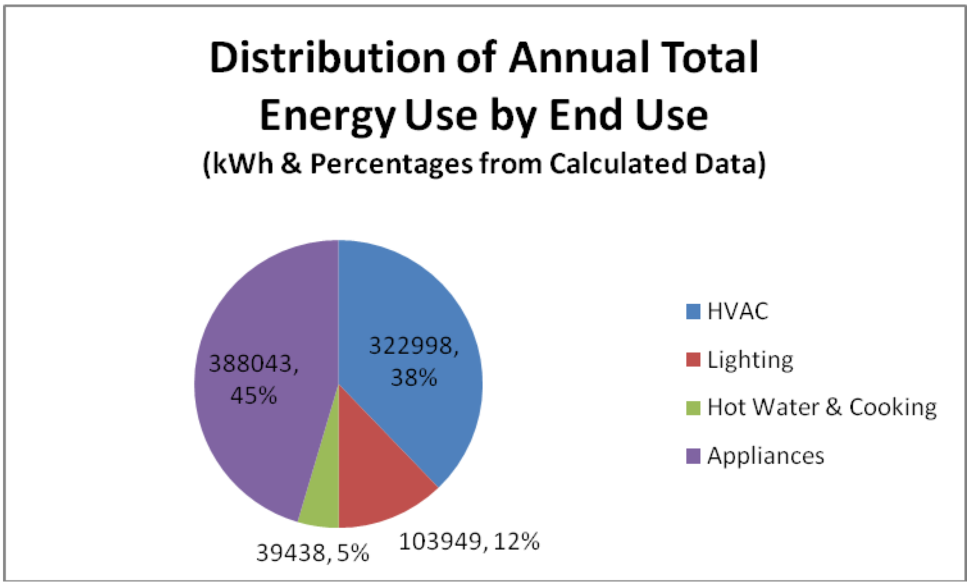

Figure 4: Walk-through audit data showing total annual energy use distribution by end use.

The proportions of energy consumption by end use, calculated from the audit results, are presented in Figure 4. Once again, all gathered data were used to compile the result.

The distribution shows that both HVAC and appliances are very large energy users in the building complex, while lighting and hot water/cooking uses are relatively small. It is important to note that the Appliances category includes not only office equipment but also refrigeration, the elevator, sliding doors and entertainment goods such as televisions and other audio/visual equipment. This may be the reason that appliances have consumed more energy than the HVAC systems, while a typical commercial building would consume the vast majority of its energy through HVAC uses. Assumptions made in the time of use of the appliances and HVAC equipment should also be taken into consideration when interpreting these results. A more detailed audit would improve the accuracy of these results.

6.2.4 Comparison with historical data and literature

The historical data show that approximately 574MWh of energy was consumed during the 12-month period analysed. The difference between this and the audit result is due to the assumed times of use for each piece of equipment or each light. It is important to note that a full user survey was not performed, and that users have control over much of the energy-using equipment, including lighting and some HVAC units.

No comparison could be made between the historical data and the calculated data in terms of proportional energy use by building. However the audit data is considered reasonable given the size, occupancy and uses of the buildings analysed.

The energy consumption by end-use is not as clear in the results. The seasonal pattern in the historical data suggest that HVAC may be the largest use, while the estimates from the walk-through audits suggest that it is second to appliance use. A more in-depth examination of the buildings would be necessary to provide further comment. The Australian Greenhouse Office estimates that energy services consume in the following (descending) order in commercial buildings:

- HVAC
- Lighting
- Appliances
- Hot Water and Cooking (Australian Greenhouse Office, 1999)

The assumptions made in the walk-through audits are certainly a major factor in the divergence from the typical commercial building energy use. It is possible that appliances account for a major portion of the energy consumption in this building complex, but much more detailed analysis would be required. This might involve a user survey to ascertain habits as well as testing of equipment, and would constitute a Level 2 or 3 energy audit.

In order to gain a view of how well the Administration building performs against energy benchmarks, the NABERS software was consulted. The input data used were the calculations from the walk-through audit, so they present errors associated with the assumptions used. The data used to perform the rating were:

- Location/postcode 4370
- Usable floorspace 1687m^2
- Number of people 80
- Number of computers 83
- Hours of occupancy 50/week
- Energy used 238,705kWh/year electricity

The result is presented below (Figure 5).

NABERS Office Rating Results

Date	24 Oct 2009	**Climate zone**	Darling Downs and Granite Belt
Site	Administration Building Fitzroy Street Warwick 4370 Queensland	**Rating type**	Whole Building
		Rated area	1687
		Hours of occupancy	50

Energy rating
Energy/Greenhouse Rating 5 stars
Fantastic performance!
You have achieved the highest possible rating.

Your building is as good as it gets. If you have done it right, you will

Other Results

Normalised emissions	121 $kgCO_2/m^2$ per annum
Raw emissions	243479 $kgCO_2$ per annum
Energy consumption	509 MJ/m^2 per annum
Green power fraction	0%
Emissions per person	3043 $kgCO_2$/person per annum
Energy per person	10741 MJ/person per annum
Area per person	21 m^2 per person

Data Inputs

People in rated area	80
Number of computers	83

Energy rating Details
Electricity 238705 kWh 0% GP (Emissions: 243,479 $kgCO_2$)

Figure 5: 5 Star NABERS rating for the Administration building, based on walk-through audit calculations (NABERS, 2008)

The Administration building rated at 5 stars based on the simple inputs required by the NABERS program. This result is not accurate simply because the value of energy consumed is greater than the actual energy consumed by the entire complex during a year. In fact, the rating may be higher within the 5 Star range, but much more detailed data would be required. The building has scored the highest rating possible; however, the energy consumption of the building can still be improved in multiple ways.

7.0 Energy Efficiency Opportunities

The opportunities and actions that follow are presented in three categories: organisational, building and end use. The costs and savings of implementation are estimates only, based on the relatively cursory information at hand during the research period. The estimates of monetary savings did not include savings that may be gained from reductions in peak demand, as the historical data available were not detailed enough to allow for this type of calculation. Monetary savings were not estimated in all cases, in an effort to comply with the confidentiality clauses contained in the electricity Service Agreement. Not all energy or money-saving options were analysed economically. The scope and time constraints of the research did not allow for acquisition of full pricing and installation quotations.

In each of the categories of energy reduction opportunities, the low hanging fruit, or the actions that can bring results by simply operating more efficiently, precede those options that carry a capital cost.

7.1 Organisational

- Develop and implement an Energy Management Strategy in accordance with development of Council's sustainability strategy - this should build upon the record-keeping that is being proposed for the strategy. Any of the following recommendations could form a part of the Energy Management Strategy.
- Implement a staff education program encouraging switching off of equipment such as computers and printers, etc after hours – this should form part of SDRC's Sustainability Strategy, and would encourage staff to get involved and take ownership of energy efficiency in Council operations. The cost of this option could range from very low (only staff time in researching and developing

the program) to much higher (a consultant's time in developing and training staff in the program). It is likely that a team of Energy Champions could be formed by interested staff members to get the program started.

- Compile and maintain records of energy consumption and costs on an ongoing basis. This option should not incur any cost, other than staff training in the early stages, while teaching them how to capture this information and develop the habit. The availability of this information would reduce the cost of any energy audit that may be commissioned at a later date.
- Update/implement an O&M regime for all major equipment to extend the life and improve performance while possibly saving energy. This could include HVAC systems, IT equipment and water heaters and kitchen appliances. The cost of this option would include staff time as well as expenses paid to tradespeople, as Council does not employ staff trained for these purposes, other than IT.
- Improve purchasing criteria and agreements to allow for Energy Star appliances to be used effectively, e.g., include a clause in the supply agreement that features are to be enabled before delivery of goods. This option need not cost Council any money, as policies are written in-house and are regularly reviewed.
- Negotiate with retailer(s) either before or upon expiration of the current agreement, in order to obtain the most appropriate tariffs and peak times. Prior research and analysis would be required into SDRC's consumption patterns, so that the best agreement could be reached. The cost of this option would be directly related to the research.
- Commission a full energy audit of all Council activities, including landfill, road works, water treatment and all building operations, for use in determining

legislative liability for GHG emissions. This would likely need to be an audit on all of Council's operations, rather than only the Administration complex in Warwick. This would be an expensive but possibly necessary option depending on legislative requirements. With proper record-keeping and monitoring by SDRC, the cost could be reduced because historical data would be easily accessible.

- Purchase accredited Green Power, as available, to reduce associated emissions and possible future legislative liabilities. This option adds expense to energy consumption, but would be beneficial in an emissions liability situation.
- Install separate electrical metering for each building and for public hire areas of Town Hall, allowing for more precise record keeping and ease of cost recovery when halls or meeting rooms are hired out. This would be a more costly option; however the result would be easier monitoring of energy consumption for management and reporting.
- Implement sub-metering for each department within administration building – this would introduce user ownership of energy use and keep it in the minds of department heads and staff if the budget is affected directly. This option would be very costly.

7.2 Building

- Encourage Library staff to only switch on public use lights and appliances during opening hours rather than from early in the morning – this would reduce the time of use of appliances and selected lighting of 10 peak hours per week, or 520 peak hours per year.
- Investigate a change in network servers or configuration of the server room. IT staff indicated that the next move in that area will be towards

virtualisation. It is estimated that virtualisation could save up to half of the current energy consumption by the network servers. There would be a cost to Council for use of software to implement virtual servers or networks, but this cost is likely to be budgeted for in the normal scheme of upgrades to the system.

- Install switches to operate the fountains outside the Art Gallery and inside the Library. (Staff and the public enjoy the fountains so it is not suggested to remove them.)
- Obtain quotations for insulation of the Town Hall roof, particularly the area above the hall itself. This space has only a floating ceiling between the events hall and the metal roof. Insulation would incur a capital outlay, but is likely to greatly reduce the amount of HVAC energy required.

7.3 End Use

- Encourage all users to shut down both computers and monitors overnight and on weekends. Note that some power would still be used overnight and on weekends due to the wall switches being left on. The figure above has attempted to account for this effect.
- Educate IT staff about the benefits and improvements to Energy Star features, particularly that operating systems and speeds are not affected in the newer equipment, as was previously the case (Dept of the Environment, Water, Heritage and the Arts, 2009). This will encourage them to enable the features on the PC's used by Council. This option need not incur any costs other than staff time in research.
- Convert incandescent lights to fluorescent or CFL where possible – this could be a clean sweep through all building areas, or just replacement as globes

burn out. This action would save on energy costs as well as globe replacement costs due to the longer life of fluorescent and CFL lighting.

- Install timers on HWS's and boiling water units, and insulating material on HWS's; also evaluate whether they are sized correctly for the usage, or if smaller units are warranted. This option would involve the cost of purchase and installation of nine timers for the six HWS's and three boiling water units.
- Investigate the viability of installing timers and/or sensors on selected lighting, e.g., bathrooms, shared office spaces and stairwells could have motion sensors with an off timer. There is also the possibility of office areas with north-facing windows to have daylight sensors attached to lighting. There would be electrician expenses incurred with this option, but analysis is warranted into how quickly the savings would outweigh the cost.
- Investigate possible changes in luminaires, or reduction in lamps in some areas – more in-depth analysis would be required to determine the appropriateness of this recommendation. This option would also likely incur some expense in both the investigation of lighting levels and in the actual retrofitting of luminaires.
- Investigate alterations to the switching for selected lighting, to reduce unneeded lights being used. For example, in the finance area walls have been shifted to create offices, and some lights in private offices are attached to the open office area lights. When the office is unoccupied, some of the lights are on inside regardless. This option would incur electrician expenses, and may not save enough money to pay for itself in an acceptable timeframe.

8.0 Recommendations

The actions recommended in this section are those for which monetary savings have been estimated, based on the basic analysis done in this research. The method used in estimating the monetary savings is as follows: the amount of time and energy saved was calculated using the audit data; the division of peak and off-peak time was calculated for the year; the times were multiplied by the peak and off-peak tariffs and then summed to result in an estimated annual cost saving. This is not a perfect system as it does not account for the time value of money or the peak demand charges. However, as this research is meant to serve as a preliminary indication of energy and money-saving opportunities, this simple method will be sufficient.

- Encourage Library staff to only switch on public use lights and appliances during opening hours rather than from early in the morning – this would reduce the time of use of appliances and selected lighting of 10 peak hours per week, or 520 peak hours per year, with a possible saving of up to $290 annually with no capital outlay.
- Investigate a change in network servers or configuration of the server room. IT staff indicated that the next move in that area will be towards virtualisation. It is estimated that virtualisation could save up to half of the current energy consumption by the network servers. Should this be the case, it would equate to about $1300 savings per year, plus some savings in use of the HVAC system. There would be a cost to Council for use of software to implement virtual servers or networks, but this cost is likely to be budgeted for in the normal scheme of upgrades to the system.

- Install switches or timers to operate the fountains outside the Art Gallery and inside the Library. (Staff and the public enjoy the fountains so it is not suggested to remove them.) If each fountain were switched off overnight, the approximate savings would be $225 per year. The Library fountain could easily be either plugged into a more accessible outlet at no cost, or plugged into a power board with a switch for up to $10, so that staff can switch it off overnight. The Art Gallery Fountain could be fitted with a timer by Council's electrical contractor at a cost of about $450. The total cost would then be about $460 if a power board were used in the Library. Assuming that each fountain is switched ON only during hours when staff are present, the simple payback period would be approximately 2 years.
- Encourage all users to shut down both computers and monitors overnight and on weekends. Based only on the Administration building computer audits carried out in this research, a possible saving of up to $3500 per year could be achieved with no capital outlay. Even more may be possible, due to the assumption that staff in other buildings switch off. Note that some power would still be used overnight and on weekends due to the wall switches being left on. The figure above has attempted to account for this effect.
- Install timers on HWS's and boiling water units, and insulating material on HWS's; also evaluate whether they are sized correctly for the usage, or if smaller units are warranted. If timers were installed, the units would not heat overnight or on weekends, with potential savings up to $2500 per year. This option would involve the cost of purchase and installation of nine timers for the six HWS's and three boiling water units. Council's electrical contractor gave a verbal quote of approximately $450 per timer, installed. For all of the units, the cost would be about $4050. With the estimated savings on water heating of about $2500 per

year in energy costs, the simple payback period would be about 1.62 years, or 1 year 8 months. This employs the assumptions that the systems actually heat for 1/3 of the time, and that the timers would be set to ON from 7am to 4pm each weekday.

The actions that require no cost, such as switching off equipment overnight, would require internal education for users in order to be effective. The group that is currently formulating the SDRC's Sustainability Strategy, has suggested using a contest to encourage a reduction in waste. This method may also be useful in forming a habit of switching off computers and other equipment overnight. The contest could be advertised in the fortnightly Staff Newsletter and if it were run for long enough, habits may be formed before the end of the competition.

There are currently signs posted on some notice boards reminding people to switch off computers. However, they are not generally near workstations, as would require more concrete support from the highest level of management. Follow up education will be important in this and in all of the suggested and recommended actions, so that Council staff understand and are reminded of the importance of energy efficiency. This will also serve to involve employees at all levels in making suggestions and decisions about energy use in Council operations.

The actions recommended in this section add up to annual estimated savings of about $7800, or 10% of annual costs, after any payback periods. Due to the use of estimated times of use, this may not be accurate, but in any case it is clear that for very little monetary investment, real savings can be made.

9.0 Conclusions

While there are some good aspects to the patterns and habits of energy use, there is much room for improvement in energy efficiency in the buildings analysed. Council is on its way to addressing some of these issues via the development and possible implementation of a Sustainability Strategy. Opportunities for improvement in energy efficiency exist in multiple sectors of energy use and in various types of changes that can be implemented, and the Strategy should address as many of these as possible.

User education is a key issue in improving energy efficiency in the operations of SDRC in Warwick. There are also organisational, building-specific and end-use specific measures to be taken that can reduce costs to Council. Any of the changes or new measures that may be implemented have the ability not only to save Council and thus ratepayers' money, but they would also serve as an example to the community that energy efficiency is not necessarily difficult and is worth any effort involved.

A more detailed review of the historical energy data, as well as a more detailed audit of each building would improve the accuracy of the results obtained in this research. However, as a first order analysis, the results can be used to steer the Council in its decision-making about energy efficiency and consumption in its operations. Further studies will be necessary at some point in the future in order to ascertain legislative liabilities. The present research can serve as a base from which to start, as well as an example of the basic steps that must be involved in such a venture.

10.0 Appendices

Appendix 1: Photos and floor plans of buildings

Figure A1.1: Administration building from the north-west. Photo taken by E Norton on 24 September 2009.

Figure A1.2: Administration building from the north-west. Photo taken by E Norton on 24 September 2009.

Figure A1.3: Administration building from the north-east. Photo taken by E Norton on 24 September 2009.

Figure A1.4: Administration building from the south, also showing car park light. Photo taken by E Norton on 24 September 2009.

Figure A1.5: Administration building from the south. Photo taken by E Norton on 24 September 2009.

Figure A1.6: Warwick Town Hall from the west. Photo taken by E Norton on 24 September 2009.

Figure A1.7: Warwick art gallery and tourist information centre from the south-east. Photo taken by E Norton on 24 September 2009.

Figure A1.8: Warwick art gallery and tourist information centre from the south-west. Photo taken by E Norton on 24 September 2009.

Figure A1.9: Warwick art gallery and tourist information centre entrance (south-east). Photo taken by E Norton on 24 September 2009.

Figure A1.10: Warwick library from the west. Photo taken by E Norton on 24 September 2009.

Figure A1.11: Warwick library south facade. Photo taken by E Norton on 24 September 2009.

Figure A1.12: Warwick library from the south-west. Photo taken by E Norton on 24 September 2009.

Figure A1.13: Warwick library from the north-east. Photo taken by E Norton on 24 September 2009.

Figure A1.14: Warwick library from the north, standing at the entry to the Art Gallery building. Photo taken by E Norton on 24 September 2009.

Figure A1.15: Warwick SES building from the north-west. Photo taken by E Norton on 24 September 2009.

Figure A1.16: Warwick SES building west facade. Photo taken by E Norton on 24 September 2009.

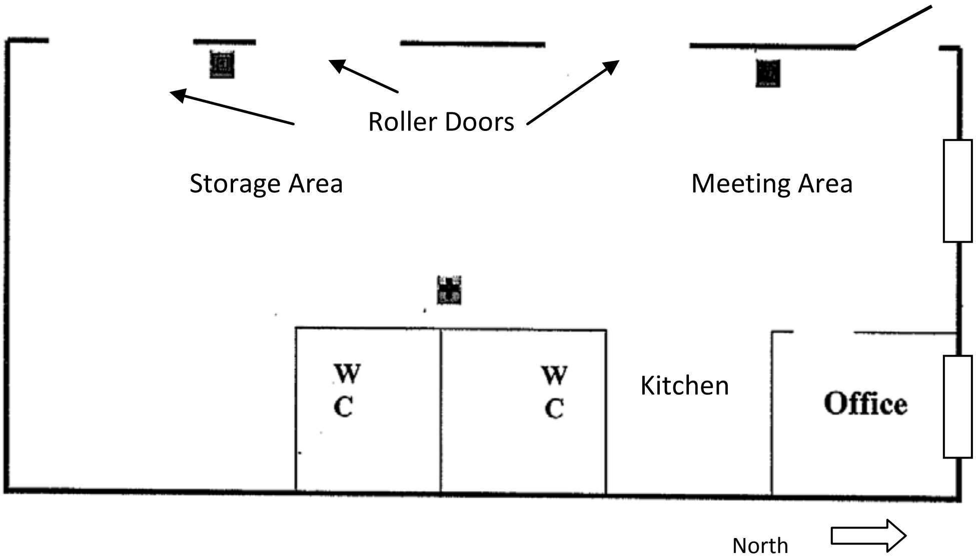

Figure A1.17: Basic Floor Plan of Warwick SES Building. Courtesy SDRC.

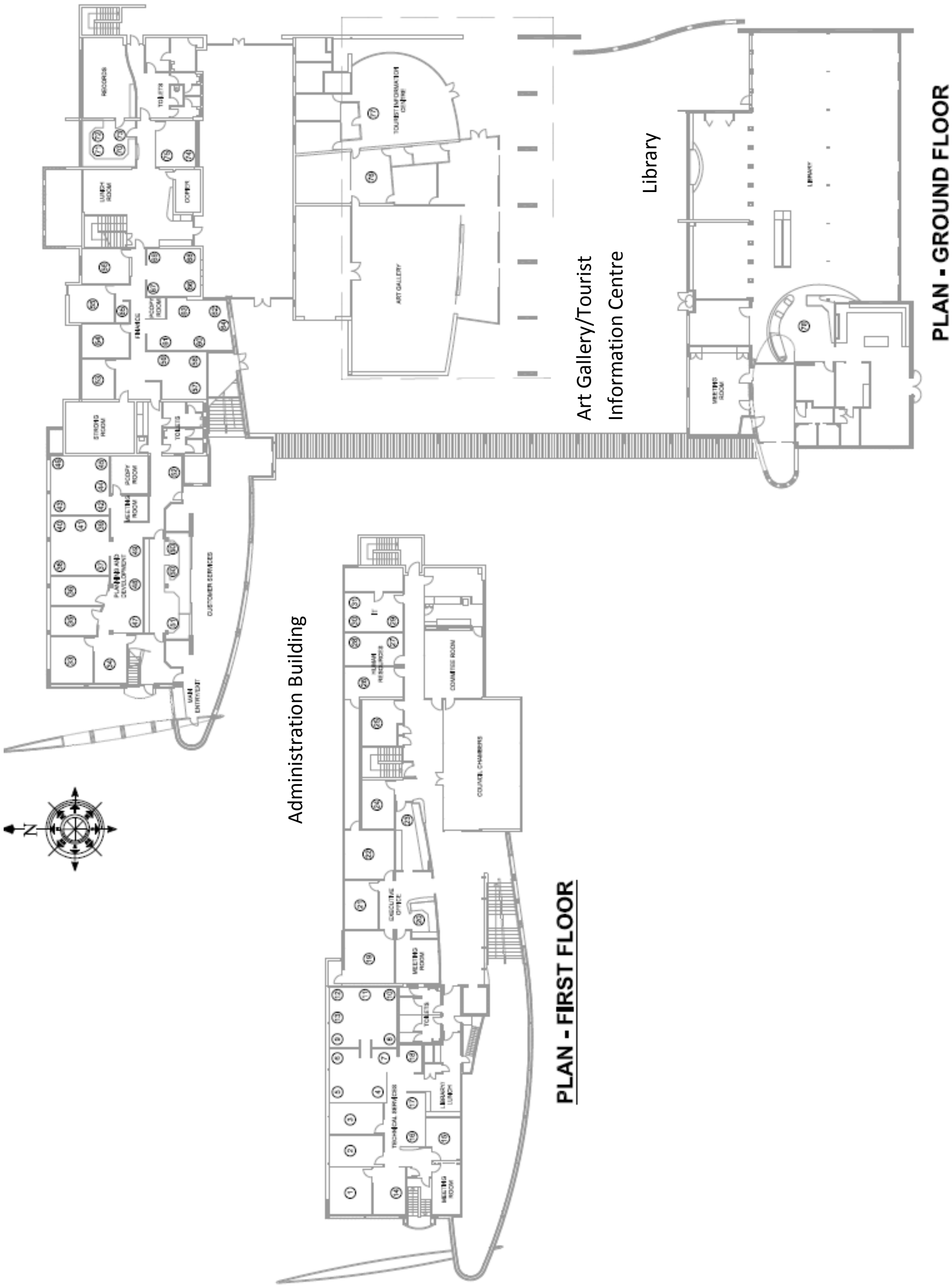

Figure A1.18: Floor Plans of Administration Building, Art Gallery/Tourist Information Centre and Library. Note that the buildings are presented in correct positions relative to one another. Courtesy SDRC.

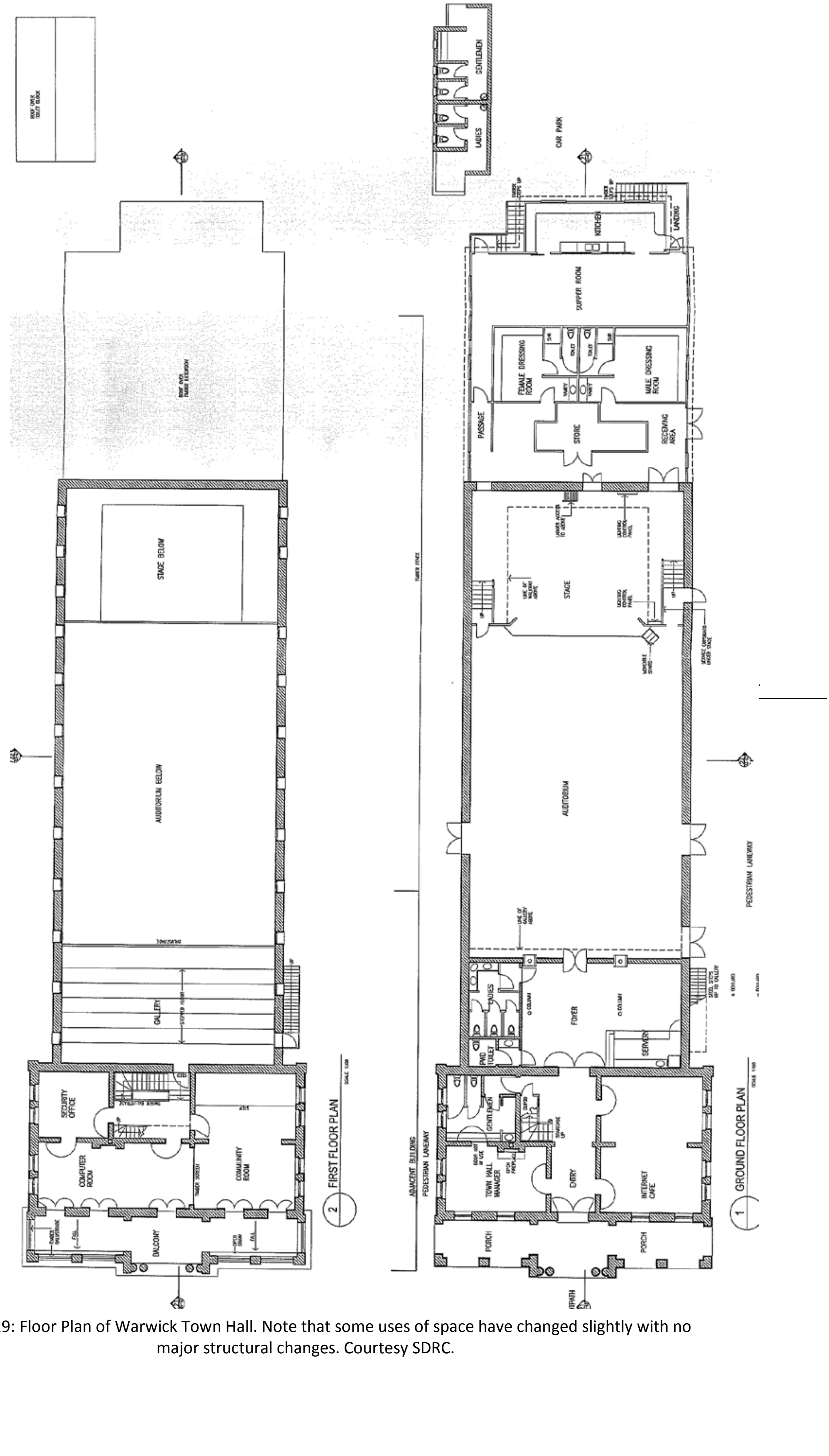

Figure A1.19: Floor Plan of Warwick Town Hall. Note that some uses of space have changed slightly with no major structural changes. Courtesy SDRC.

Appendix 2: Assumptions employed

The important assumptions employed in the calculations of energy used in the walk-through audits are described below.

In using the limited historical energy consumption data, it was assumed that the 12-month period analysed is typical of every year. It was further assumed that this data remains static from year to year, without any increasing trend. Additionally, the assumption was made that no decrease in consumption would occur should current operational practices be maintained over time.

The number of people occupying each building during operational hours was estimated based on assumptions of staff attendance. Numbers of members of the public were estimated for the Library, Gallery and Town Hall based on information provided by staff at each facility and the capacity of each facility.

The time of use of each piece of equipment was estimated using information from the FMO in most cases. Additional estimates were made by the auditor, particularly in the Administration building, as a building occupant.

Measurements of the HVAC units were taken by a tradesperson, while on heating mode. The only exception was the two units inside the server room, which are always used for cooling and their consumption was assumed to match the manufacturer’s statement. The other units were assumed to operate at 95% of the heating measurement, while in cooling mode. This assumption is based on all the available manufacturer statements for the units.

It was further assumed that all units except those in the server room operate in cooling mode 70% of the time and in heating mode only 30% of the time over a year. This assumption is related to the climate of Warwick, whereby heating is needed in winter, but the other seasons are comfortable to hot outside. The fact that office equipment operates all year inside the buildings is assumed to cause cooling to be required even during spring and autumn. Based on this distribution of heating and cooling through the year, and the previous assumption on the consumption in each mode, the average rating used for daily calculations was combined to give 96.5% of the measured heating mode power.

A power factor of 0.8 was assumed for all HVAC units, refrigeration units and other motorised equipment including computers. A power factor of 1.0 was assumed for all lighting and water heating equipment.

All water heating units were assumed to actively heat for one third (1/3) of the time, as water is used and replaced in the system. The estimated savings from using timers on these systems also employed the assumption that the timers would be set to ON each weekday from 7:00am to 4:00pm, including public holidays. This could lead to an underestimate of energy savings.

Appendix 3: Wind roses for Warwick

The following wind roses were sourced from the Bureau of Meteorology (Australian

BoM, wind, 2009).

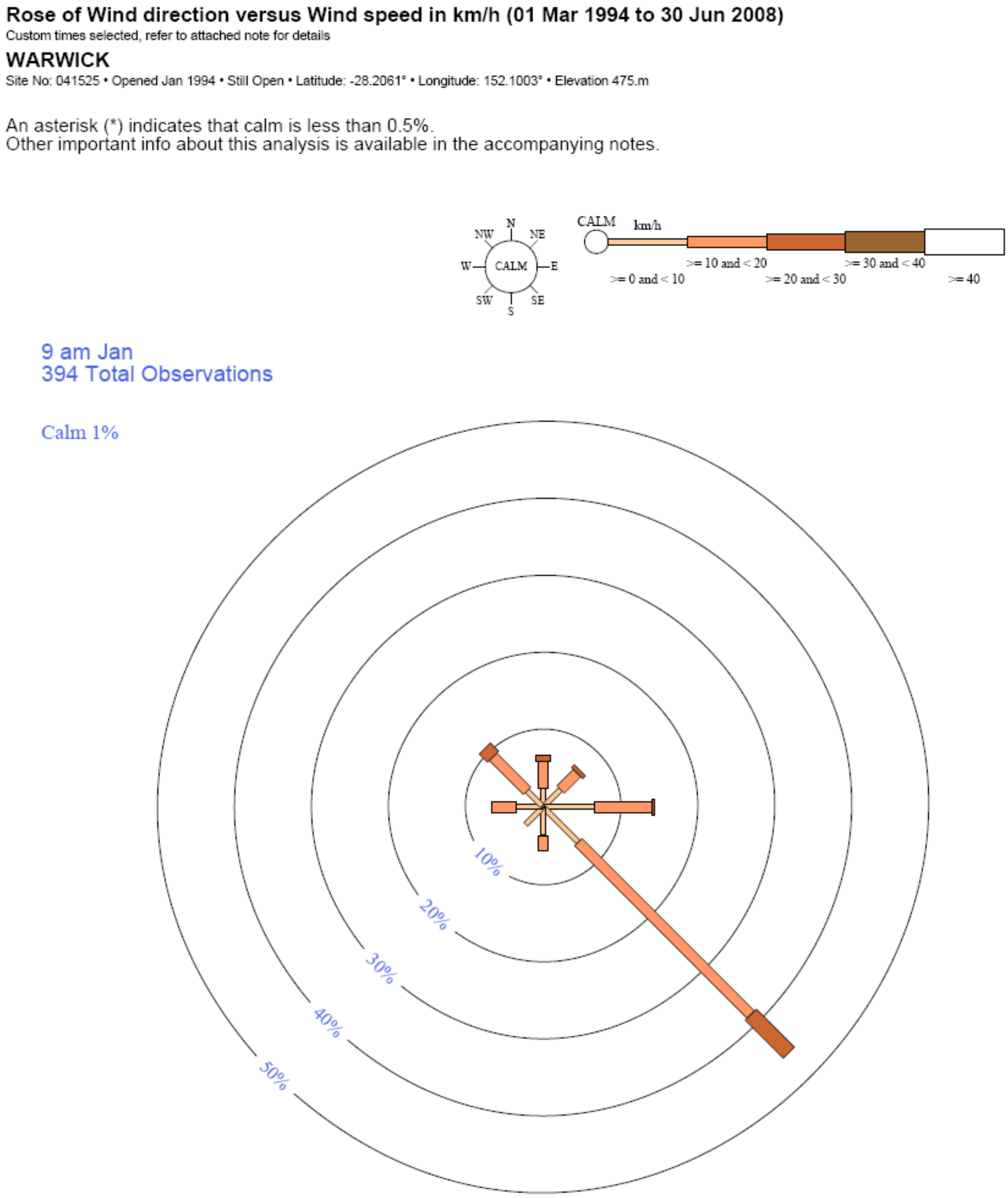

Figure A3.1: Warwick wind rose, 9am January

Rose of Wind direction versus Wind speed in km/h (01 Mar 1994 to 30 Jun 2008)
Custom times selected, refer to attached note for details

WARWICK
Site No: 041525 • Opened Jan 1994 • Still Open • Latitude: -28.2061° • Longitude: 152.1003° • Elevation 475.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.

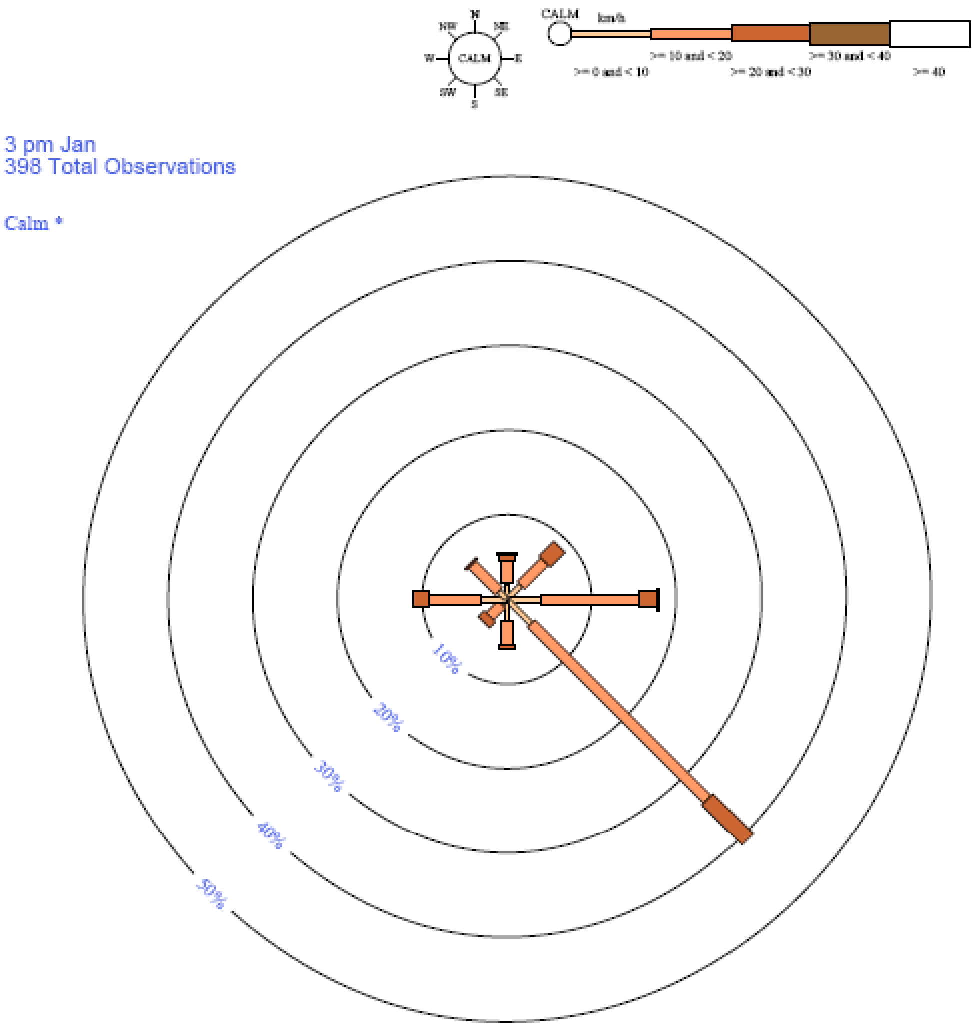

Figure A3.2: Warwick wind rose, 3pm January

Rose of Wind direction versus Wind speed in km/h (01 Mar 1994 to 30 Jun 2008)
Custom times selected, refer to attached note for details

WARWICK

Site No: 041525 • Opened Jan 1994 • Still Open • Latitude: -28.2061° • Longitude: 152.1003° • Elevation 475.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.

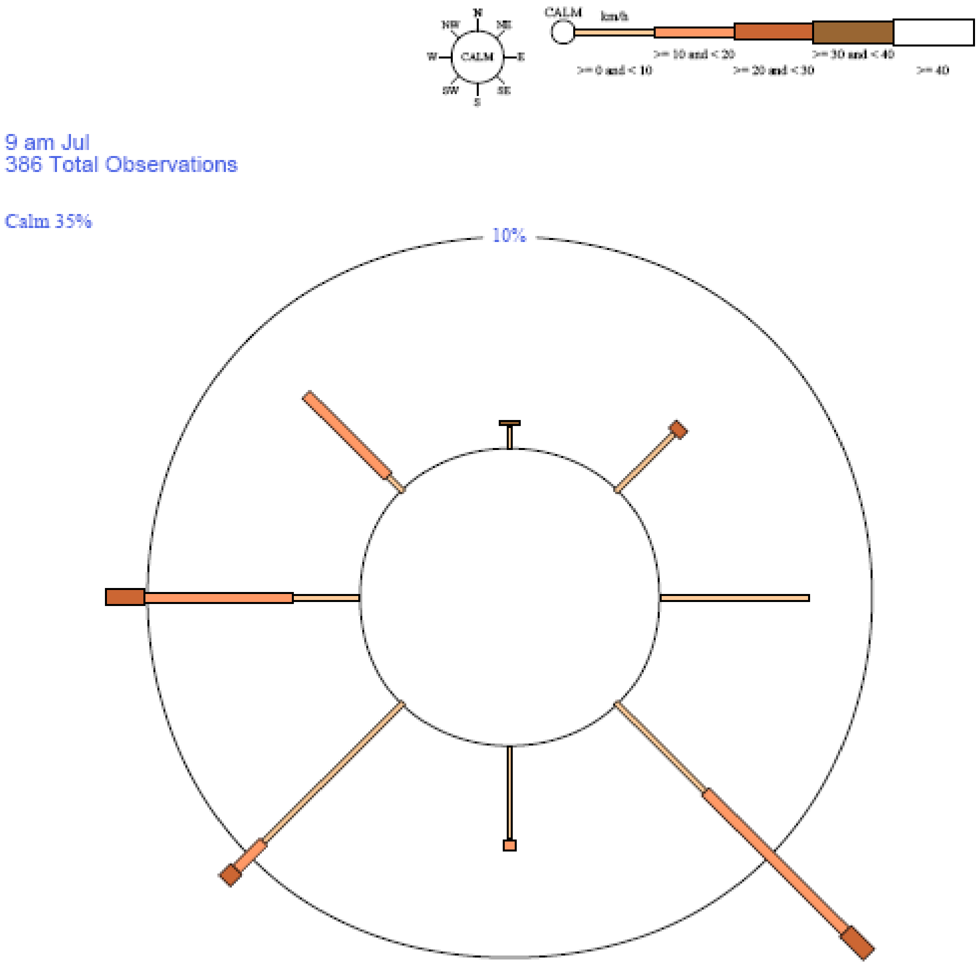

Figure A3.3: Warwick wind rose, 9am July

Rose of Wind direction versus Wind speed in km/h (01 Mar 1994 to 30 Jun 2008)
Custom times selected, refer to attached note for details

WARWICK

Site No: 041525 • Opened Jan 1994 • Still Open • Latitude: -28.2061° • Longitude: 152.1003° • Elevation 475.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.

3 pm Jul
390 Total Observations

Calm 2%

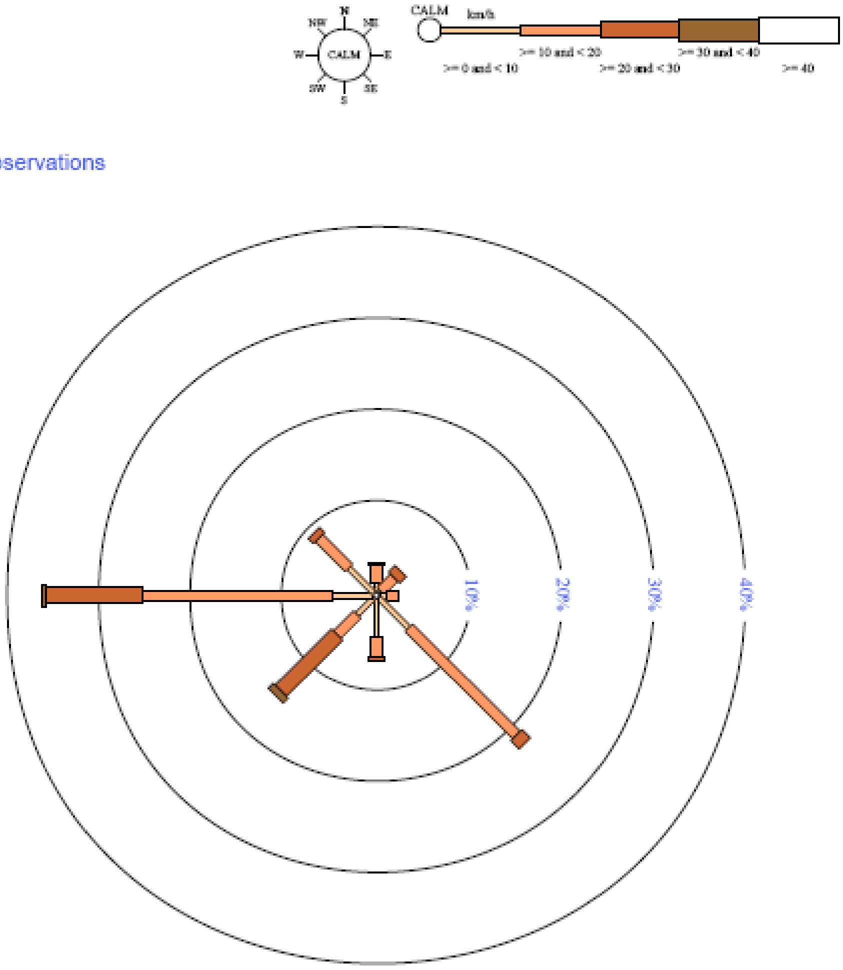

Figure A3.4: Warwick wind rose, 3pm July

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